Radiation Belt Storm Probes (RBSP) Sample Ephemeris Version 2

So that responders to the RBSP Announcement of Opportunity NNH05ZDA003O may propose to a single RBSP mission concept, the ASCII ephemeris files with the names:

"RBSP1_Sample_Ephem_V2.txt"

and

"RBSP2_Sample_Ephem_V2.txt"

are provided. These files repeat and also augment the information contained in the previously released ephemeris and description files "RBSP_Sample_Ephem_V1.txt" and "RBSP_Sample_Ephem_V1_Description.doc". The ephemeris files contain collimated ASCII information about the orbital positions of the two Radiation Belt Storm Probes (RBSP) as determined during pre-Announcement of Opportunity mission concept studies. This concept orbit design is based on one of many possible sets of mission parameters. The final orbit design will be based on the mission science requirements that will be determined through the RBSP Announcement of Opportunity NNH05ZDA003O. The information contained in these new files that was not contained in the originally released file includes the positions of the two spacecraft in the GSE coordinate system (defined below) as well as the unit vector that points from the Earth to the Sun as expressed in the Geographic coordinate system.

For this notional mission, as previously described in "RBSP_Sample_Ephem_V1_Description.doc", the spacecraft are inserted into nearly identical orbits with perigee ~500 km altitude, apogee: ~5.8 Earth radii geocentric distance, and inclination: 18 degrees. Both spacecraft begin their journeys at identical perigee positions at 0000 UT on 1 February 2011 with both lines-of-apsides beginning with an angle to the geographic equator roughly equal to the orbit inclination. The apogee of spacecraft number 2 (SC2) is roughly 120 km lower than the apogee of spacecraft number 1 (SC1) so that SC2 has a shorter orbital period than does SC1. Specifically SC2 laps SC1 once every ~91 days, or roughly 4 times a year. The actual mission will likely be launched on a different day and time and at a different local time than represented in this file. Engineering constraints, such as achieving solar illumination on solar panels during early operations, have not been folded into this notional mission. The parameters that specify the RBSP1 and RBSP2 orbits at the beginning of their missions are:

<u>LWS-RBSP1 orbit</u>

apogee radius	36978.140000 km
perigee radius	6878.140000 km
inclination	18.0 deg
Arg. of perigee	265.5 deg
RAAN	290.3 deg
MA	0.0 deg
Period	32315.71 sec

LWS-RBSP2 orbit

apogee radius	36858.380000 km
perigee radius	6878.140000 km
inclination	18.0 deg
Arg. of perigee	265.5 deg
RAAN	290.3 deg
MA	0.0 deg
Period	32183.43 sec

These "Version 2" ephemeris files contain the positions of the 2 spacecraft as a function of time in three different coordinate systems: 1) The Earth-oriented geographic system (radius, longitude, and latitude), 2) the Geocentric-Solar Ecliptic (GSE) system, and 3) the Geocentric-Solar-Magnetospheric (GSM) system, as defined by Hapgood (1992) and Kivelson and Russell (1995). Specifically, the GSE coordinate system is centered on Earth, has its X-axis pointing exactly at the sun, and has its Z-axis pointing towards the north ecliptic, exactly perpendicular to the Earth's orbital plane. The Y-GSE axis completes the right-handed coordinate system, pointing in the direction opposite orbital motion. The GSM coordinate system is centered on Earth, has its X-axis pointing exactly at the sun, and has its roughly northward pointing Z-axis configured so that the Earth's magnetic dipole axis is contained within the GSM X-Z plane. The Y-GSM axis completes this right-handed coordinate system. The first of the two files described here also contains the unit vector that points from the center of the Earth towards the Sun expressed in the Geographic coordinate system. The orbital positions are sampled at a cadence of 5 minutes. For the two files described here, the file columns contain:

"RBSP1_Sample_Ephem_V2.txt"
Day of Month (e. g. "12" or " 3"; single digits have a leading space)
Month (e. g. "Feb")
Year (e. g. "2011")
Hour:Minute:Second (e. g. "02:05:32.124")
Day since the beginning of 2011 (e. g. "31.04166667")
SC1 radial distance (km)
SC1 longitude (deg)
SC1 latitude (deg)
SC1 GSEX (km)
SC1 GSEY (km)
SC1 GSEZ (km)
SC1 GSMX (km)
SC1 GSMY (km)
SC1 GSMZ (km)
Earth-to-Sun Unit X (Geographic coordinates)
Earth-to-Sun Unit Y (Geographic coordinates)
Earth-to-Sun Unit Z (Geographic coordinates)

"RBSP2_Sample_Ephem_V2.txt"
Day of Month (e. g. "12" or " 3"; single digits have a leading space)
Month (e. g. "Feb")
Year (e. g. "2011")
Hour:Minute:Second (e. g. "02:05:32.124")
Day since the beginning of 2011 (e. g. "31.04166667")
SC2 radial distance (km)
SC2 longitude (deg)
SC2 latitude (deg)
SC2 GSEX (km)
SC2 GSEY (km)
SC2 GSEZ (km)
SC2 GSMX (km)
SC2 GSMY (km)
SC2 GSMZ (km)

The column entries are separated by multiple spaces, and single digit entries in the first column have a leading space. The two files contain identical entries in terms of the sampling in time. Thus, record "n" in the first file corresponds to exactly the same time as record "n" in the second file.

Interest has been expressed in obtaining the spacecraft trajectory information in the Solar-Magnetospheric (SM) coordinate system (Hapgood, 1992; and Kivelson and Russell, 1995). SM is generated from the GSM system by rotating around the GSM-Y axis until the Z-axis is exactly aligned with the Earth's magnetic dipole axis while pointing within the northern hemisphere of the Earth. Spacecraft trajectories within the SM system are easily generated using the information contained within the files provided here. The angle ("rot") that one must rotate around the GSM-Y axis to turn the GSM system into the SM system is determined by calculating, on a record-by-record basis, the angle ("offset") between the Earth-to-Sun unit vector provided here (in Geographic coordinates) and the negative of the magnetic dipole axis (provided by the user in geographic coordinates; the "negative" direction is used because the magnetic dipole points towards the Earth's southern hemisphere). The magnitude of "rot" is then just |90 degrees – offset|. Because of possible ambiguities in the definition of rotation direction, the determination of the sign of "rot" is left to the user.

References

M. A. Hapgood, "Space physics coordinate transformations: A user guide", in Planetary and Space Science, Vol. 40, No. 5, pp. 711-717, 1992.

M. G. Kivelson and R. T. Russell, Introduction to Space Physics, Cambridge University Press, Cambridge, 1995.